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rent sucking apparatus in the body, and the only use I can assign to the structure just described, is that of a *pumping organ.* It is probable that the liquid food is sucked into the pharynx by the contraction of the muscles which are attached to the chitinous threads; this process enlarges the pharynx cavity by lifting the roof. From the pharynx the food passes, by muscular contraction, down the œsophagus. [Plates to follow with succeeding number.]

(To be continued.)

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THE CREODONTA.

BY E. D. COPE.

PRESENT knowledge justifies the generalization that, since the Eocene period, the mammalian fauna of the Northern hemisphere has diminished in the number of its species and genera. The Eocene fauna was richer than the Miocene; the Miocene than the Pliocene, and the Pliocene was richer than the modern fauna. With this numerical diminution in species has come increased specialization of structure, which means both greater perfection of mechanism and greater diversity of type.[1]

The order of Carnivora is a universal and well-known factor of the mammalian life of the present period. It was equally so in the Pliocene and Miocene periods. When we come to examine the overflowing life of undoubted Eocene time, we can no longer find mammals which possess the essential characters of the order. The Carnivora are unguiculate gyrencephalous mammalia with a coössified scaphoid and lunar bone of the carpus, called, therefore, the scapholunar bone. They have a grooved astragalus. No scapholunar bone has yet been found in any Eocene mammal in North America, and it is doubtful whether any has been found in Europe. Nevertheless the Eocene fauna did not lack predatory flesh-eaters whose function was like that of the Carnivora of later periods, to restrain the undue increase of all other forms of life. Their variety was greater than that presented by their carnivorous successors on the North American continent, and their numbers were proportioned to the general luxuriance of the life which furnished them subsistence. There were species whose size and powers of destruction equaled those of the bears, lions and tigers of modern times. Species of medium size abounded, while the smaller forms, representing in function the civets and weasels of to-day, were especially numerous.

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[1] This generalization was published in the Report U. S. G. G. Survey W. of 100th meridian, 1877, IV, p. 385.

The systematic position of these animals has been difficult to determine with satisfactory precision, owing to the imperfect knowledge which we possess of their structure. Besides lack of scapholunar bone, they nearly all differ from the Carnivora in their ungrooved astragalus, and their greatly reduced and smooth cerebral hemispheres. Their position then can only be with the Marsupialia or the Insectivora. The superficial resemblances are often to the former order, where the carnivorous types Thylacinus, Sarcophilus, Dasyurus and the opossums, seem to present near affinities, if the structure of the teeth only is to be considered. Laurillard, DeBlainville and Gaudry have, at different times, assigned to them this position. It is true, however, that no one osseous character, except the possession of marsupial bones, has yet been discovered which characterizes the order Marsupialia. It rests chiefly on the characters of its soft parts, especially of the brain and reproductive system. Most marsupials have the angle of the lower jaw inflected; the Eocene flesh-eaters do not. The carnivorous marsupials generally have more than six incisor teeth; the Eocene flesh-eaters have six or less. The marsupials generally have perforated palates; the Eocene forms never display the character. No marsupial bones have yet been found in the Eocene forms (with the possible exception of Mioclænus), so that we cannot yet find the necessary reasons for placing our extinct forms with the order which possesses them. On the other hand the brain was probably marsupial in its internal character, as it certainly was in its external character. Finally, the discovery of the character of the temporary dentition in the Eocene flesh-eaters has added force to the view that they cannot be marsupials. M. Filhol has shown that in Hyænodon there were three temporary molars, and I have proven that there were at least two in Triïsodon. There is, according to Flower, but one in the Marsupialia. It is, however, to be remembered that true marsupials, opossums, occur in the Oligocene in both North America and Europe (genus Peratherium Aym.), and that they resemble their Eocene predecessors very much, especially in the constitution and form of the molar teeth.

The comparison with the Insectivora betrays no such fundamental diversities as that with the Marsupialia. The differences are of minor import, although in particular cases considerable. In spite of their often large size and evidently predatory habits, the Eocene flesh-eaters must be placed with the Insectivora. But as I have already pointed out,[1] they have contemporaries which must go with them. These are two groups, the one with rodent, the other with edentate tendencies, the Tillodonta and Tæniodonta. The former of these is intimately allied to the living Chiromys of Madagascar, which itself is almost a lemur, by general consent. The whole of this assemblage I have regarded as an order of mammals to which I have given the name of the Bunotheria. In this order there are included six suborders, and

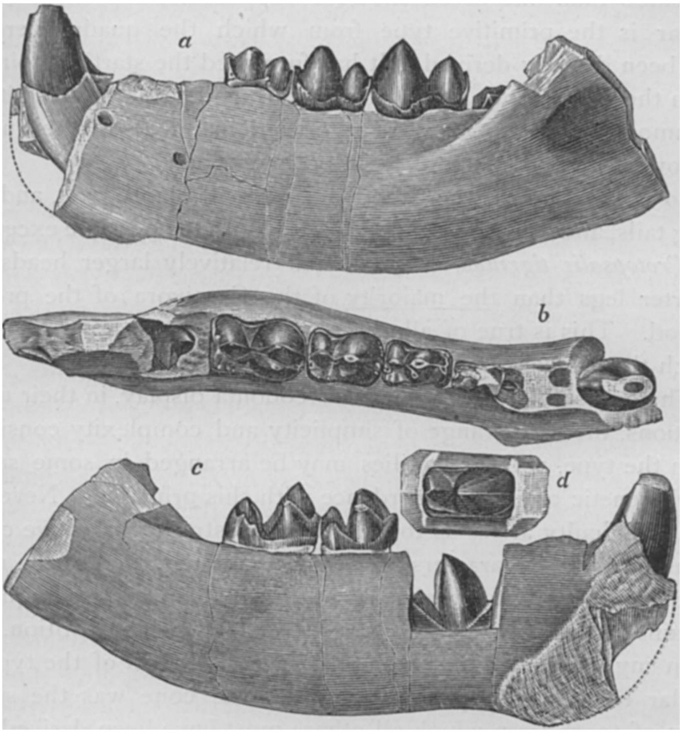

FIG. 1.—Left mandibular ramus of *Triïsodon quivirensis* Cope, three-fourths nat. size, from the Puerco beds of New Mexico. Fig. *a*, external view, displaying the last temporary molar in place; *b*, the same from above; *c*, the same, internal side, the temporary molar removed and the permanent fourth true molar displayed in the jaw; *d*, the fourth permanent premolar viewed from above. Original; from Vol. IV, Report U. S. Geological Survey Terrs., F. V. Hayden in charge.

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[1] Report U. S. G. G. Surveys W. of 100th meridian, G. M. Wheeler in charge, IV, p. 85, 1877. Proceedings Academy Philadelphia, 1883, p. 77.

the carnivorous type of this series, the group now under discussion, I have called the Creodonta.[1] Its definition is as follows:

Neither incisor nor canine teeth growing from persistent pulps. Hallux not opposable. Superior true molars tritubercular or more simple.

The only character which distinguishes the suborder from the Insectivora is the possession of tritubercular or more simple molars above. This is, as I have shown,[2] a feature of more importance than has been hitherto supposed. The tritubercular molar is the primitive type from which the quadritubercular has been directly derived. It has furnished the starting point for both the carnivorous and the herbivorous dentitions, since it was common to both the clawed and hoofed mammals of the Puerco, or lowest known epoch of the Eocene period.

So far as known, the Creodonta were all plantigrade, and had long tails, and were mostly five-toed. With the possible exception of *Protopsalis tigrinus*, they all had relatively larger heads and shorter legs than the majority of the Carnivora of the present period. This is true of all the recent Creodonta, none of which reach the dimensions of many of the fossil forms.

The contents of the suborder Creodonta display, in their modifications, the usual range of simplicity and complexity consistent with the type, and the families may be arranged in some sort of phylogenetic order, in accordance with this principle. Nevertheless a difficulty arises as to what are ancestral or primitive conditions, and what characters, if any, must be regarded as the result of degradation. As other parts of the skeleton are less frequently obtained, these considerations relate chiefly to the dentition.

In my paper on the Homologies and Origin of the types of Molar Teeth, etc.,[3] I pointed out that the cone was the simple form of tooth from which all others must have been derived. In the Mammalia this may have been modified in several ways simultaneously, but two methods present themselves as the most certain secondary primitive types. The first of these is that of the simple premolar, where the cone is compressed, and is sooner or later followed by a horizontal extension or heel. This type persists in the inferior true molars of the Mesonychidæ. The second modification consists in the addition of lateral cusps or spines to the simple cone. Such a type is seen in inferior molars of *Spalacotherium tricuspidens* Ow., of the Jurassic period, and in some of the incisors of *Plesiadapis tricuspidens*[1] Gerv. This form, by the shifting of the two subordinate cusps to the inner side of the principal one, will give a trituberculate molar of the lower series, an exaggeration of which is seen in the South African "mole," Chrysochloris. If a cingulum appears at the posterior base of such a tooth, we have a rudimental "heel," such as is seen in Centetes, and is still better developed in many creodont and marsupial genera, forming the basis of the inferior sectorial tooth of the Carnivora. This, which I have called the "tubercular-secto-

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[1] For greater detail on this topic, see Proceedings Philadelphia Academy, 1883, p. 77.

[2] Proceedings American Philosophical Society, 1883, p. 324. Palæontological Bulletin, No. 37.

[3] Journal Academy Nat. Sciences Philada., 1874, March.

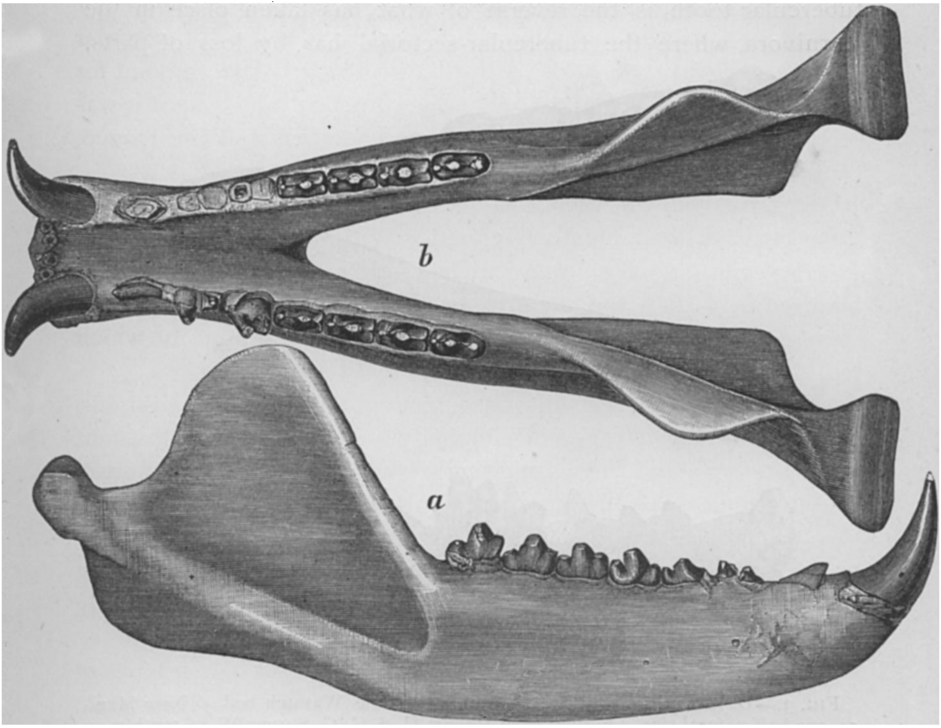

FIG. 2.—Mandible of *Mesonyx ossifragus* Cope, from the Wasatch epoch of the Big Horn river, Wyoming, one-third nat. size. Original. From Report U. S. G. S. Terrs., Vol. III.

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[1] Lemoine. Communication sur les Ossemens Fossiles d. env. Reims, p. 9, pl. II, fig. 13. The superior dentition of this specimen is represented in fig. 6.

rial," is especially well marked in Oxyæna (Fig. 3) and Stypolophus.

All stages of diminution of the anterior of the two inner cusps of the inferior molars may be seen in the genera of Centetidæ, as for instance in Ictops and Diacodon, until a true quadrituberculate molar is reached as in Mioclænus. In Miacis and Didymictis one tubercular-sectorial remains with one or more tuberculars. The process of developing a tubercular inferior molar from a tritubercular tooth, is the reverse of what has taken place in the Carnivora, where the tubercular-sectorial has, by loss of parts, become a true sectorial. With these explanatory remarks I present the following definition of the families. I have formerly used the shape of the astragalus as a family definition. In the majority of the Creodonta its trochlear face is not grooved. In the Mesonychidæ it is strongly grooved. In Mioclænus and some species of Stypolophus, as well as in the moles, it is slightly grooved :

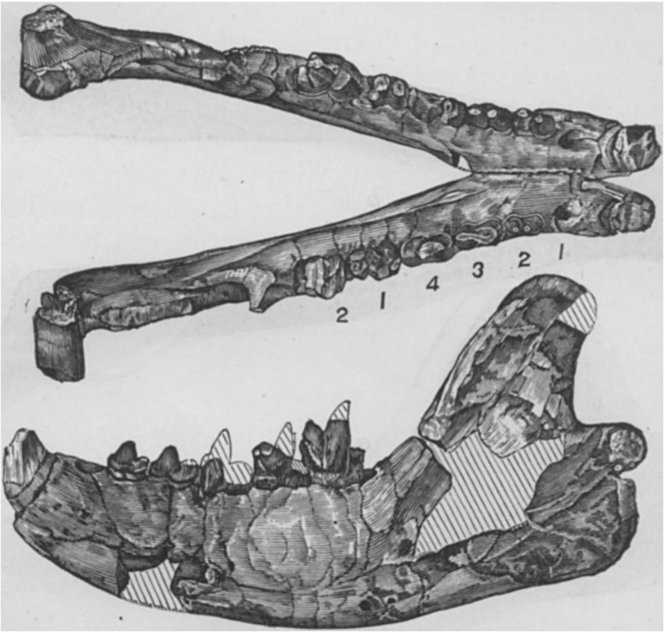


Fig. 3.—*Oxyæna forcipata* Cope, mandible from the Wasatch bed of New Mexico, one-half natural size. Original from Report U. S. G. G. Survey W. of 100th mer. G. M. Wheeler, Vol. IV. The numbers indicate the approximate premolars and true molars.

I. Inferior molars premolariform.

Inferior molars consisting of a cone and heel......................*Mesonychidæ.*

Inferior molars with a blade formed of anterior and median cusps...*Hyænodontidæ*

II. Inferior molars tritubercular without heel.

No sectorial teeth; tibia and fibula coössified.................... *Chrysochlorididæ.*

III. Inferior molars tritubercular-sectorial or quadritubercular.

a. No superior sectorial teeth.

Tibia and fibula distinct.. *Centetidæ.*

Tibia and fibula coössified; external tubercles of superior molars subconic, no clavicles... *Mythomyidæ.*[1]

Tibia and fibula coössified; external tubercles two Vs; clavicles........ *Talpidæ.*

aa. First true superior molar sectorial.

Tibia and fibula distinct; no tubercular molars...................... *Oxyænidæ.*

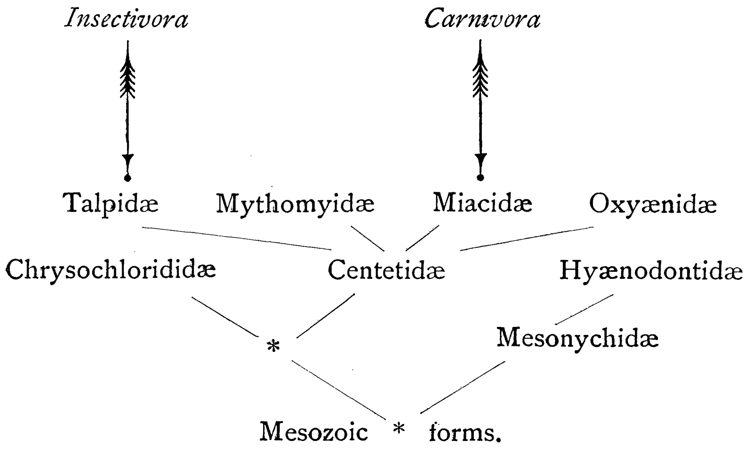
aaa. Fourth superior premolar sectorial.

Tibia and fibula distinct; true molars tubercular..................... *Miacidæ.*

The number of genera and species embraced by these families is as follows. The extinct forms only are enumerated, and those of North America are specified:

Families.	*Genera.*	*Species.*	*N. America.*
Mesonychidæ	4	7	7
Hyænodontidæ	1	10	3
Chrysochlorididæ	*	*	
Centetidæ	18	44	37
Mythomyidæ	*	*	
Talpidæ	*	*	
Oxyænidæ	3	7	4
Miacidæ	2	12	12
Totals	28	80	63

The affinities of these families may be expressed in the following diagram, which may be regarded as an attempted phylogeny also:



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[1] This family is sometimes called the *Potamogalidæ.* Mythomys is, however, the name first published, with a description, for the typical and only genus.

In geological time the Mesonychidæ, Miacidæ and Oxyænidæ are confined to the Eocene period. The Hyænodontidæ extend through the Upper Eocene and Oligocene or Lowest Miocene formations. The Centetidæ are predominately Eocene, but in North America they are also found in the Oligocene. In recent times they are only known in the islands of Madagascar and Cuba. The Chrysochlorididæ are modern and African, while the Talpidæ commence in the Middle Miocene in Europe, and are as abundant in recent times in the Northern hemisphere. Mythomyidæ are only known as recent in Africa. These relations may be expressed as follows:

	Eocene.		*Miocene.*		*Recent.*
	Lower.	Upper.	Lower.	Upper.	
Mesonychidæ	———	———			
Hyænodontidæ		———	———		
Chrysochlorididæ					———
Centetidæ	———	———	———	———	———
Mythomyidæ					———
Talpidæ				———	———
Oxyænidæ	———	———			
Miacidæ	———	———			

The distribution of the genera with relation to the American formations will be considered later.

MESONYCHIDÆ.

In this family the form of the inferior molars is not very different from that displayed by the last lower premolars of carnivorous Mammalia generally. The superior molars are of correspondingly simple structure, in like manner resembling the last premolars of the superior series of Carnivora and some other Mammalia. There are two types in the family. In the first, the astragalus is flat, as in most Creodonta (Fig. 5 *a b*). The only known genus is Amblyctonus, which I have, on account of its astragalus, placed in a separate family, the Amblyctonidæ. This course may be justified by future discovery. The inferior molars also differ from those of Mesonyx in the development of the anterior cusp, thus approaching the Hyænodontidæ (Fig. 4). The bones of *Amblyctonus sinosus* Cope, are about as robust as those of the coyote. They have so far been found only in the Wasatch beds of New Mexico. M. Fischer has described an allied mammal from France under the name *Apterodon gaudryi.* He has not stated how this genus differs from Amblyctonus.

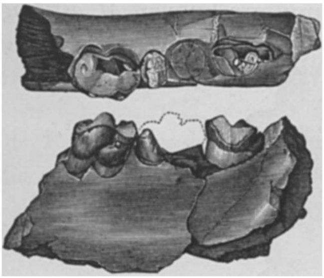

Fig. 4.

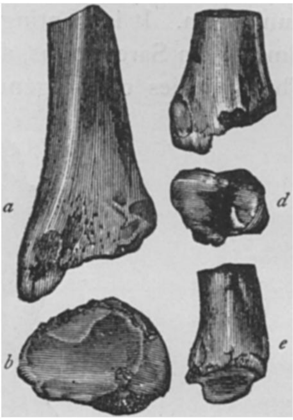

Fig. 5.

FIG. 4.—Part of mandibular ramus of *Amblyctonus sinosus* Cope, with the last three molars ; upper figure the same, from above; two-thirds nat. size. From the Wasatch beds of New Mexico. FIG. 5.—Distal ends of tibia of, *a–b*, *Amblyctonus sinosus*, and *c d e*, *Oxyæna morsitans* Cope; *b* and *d*, distal views; two-thirds natural size. From the Wasatch beds of New Mexico. Original, from U. S. G. G. Expl. Surv. W. of 100th mer., G. M. Wheeler.

In the genus Mesonyx we have a structure of the astragalus found only elsewhere in flesh-eating mammals in the Hyænodon.[1] Its distal extremity has two well-marked facets, one for the navicular bone and one for the cuboid (Fig. 9). The appearance is that of a perissodactyle mammal, and the astragalus of the Mesonyx might well be taken for that of an ungulate of that suborder. The tibial face of the bone is grooved, another point in which it differs from most of the Creodonta. Still another characteristic peculiarity is seen in the forms of the ungues. These are neither claws nor hoofs, but between the two, resembling the corresponding part in some Rodentia. Their deeply fissured extremities show that they are rather allied to claws than to hoofs (Fig. 10). The narrow navicular facet of the astragalus renders it probable that the inner digit or hallux is wanting, and that there are but four toes in the hinder foot. The form of the trapezium shows that there are but four toes on the anterior foot (Fig. 7). One more character completes the singular ensemble presented by this genus. The zygapophyses of the lumbar vertebræ embrace each other as in the lower perissodactyles and artiodactyles, a character not found in the Carnivora or Insectivora.

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[1] Fide Professor W. B. Scott.

Among the Creodonta I have only observed it elsewhere in the genus Mioclænus,[1] but the vertebræ of many of these animals are unknown. It is wanting in Thylacinus and the opossum, and rudimental in Sarcophilus, among marsupials.

Three species of the genus Mesonyx are known, *M. ossifragus* Cope, from the Wasatch Eocene, and *M. lanius* and *M. obtusidens* Cope, from the Bridger. The last named is the type. It is about the size of the wolf, and had more slender feet and claws than

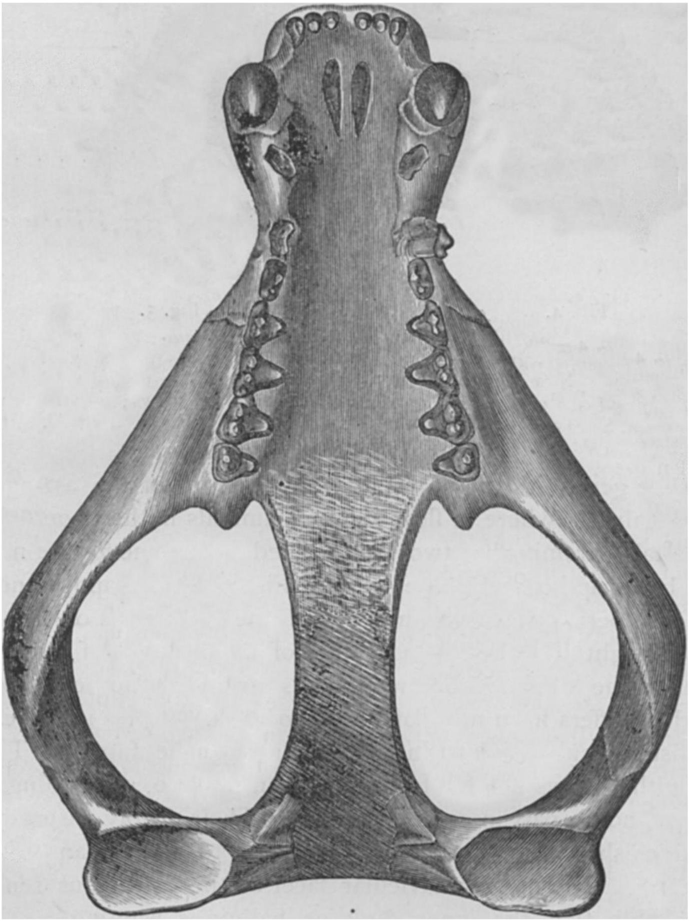

FIG. 6.—*Mesonyx ossifragus* Cope, skull anterior to postglenoid processes, inclusive, from below; one-third natural size. From the Wasatch beds of Wyoming. Original, from Report U. S. Geol. Surv. Terrs., III, F. V. Hayden.

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[1] Proceedings American Philos. Society, 1883, p. 543.

the other two. The *M. lanius* was considerably larger than the *M. obtusidens,* equaling the black bear (*Ursus americanus*) in size. It had a large head, with a long, rather narrow and truncate muzzle. The limbs were relatively smaller, not exceeding those of the black bear in length and thickness. The tail was long and slender as in the cats, while the claws were broad and flat as in the beaver.

The molar, canine and incisor teeth of my specimen, as well as those of one in the Princeton Museum, are much worn by use. This is especially true of the canines of both, while the crowns of the molars of my Bitter Creek specimen are almost entirely worn away. The same peculiarity is to be observed in the specimens of the allied *Amblyctonus sinosus,* which I obtained in New Mexico. It is probable that these species chewed hard substances. The peculiar approach of the lower canines is a special modification for peculiar habits, which I suspect to have been the devouring of the turtles which so abounded on land and in the waters of the same period. The slender symphysis could most readily be introduced into the shell, while the lateral pressure of the upper canines with the lower, would be well adapted for breaking the bony covering of those reptiles. The breaking of these shells in the attempt to masticate their contents would produce the unusual wear of the teeth observed.

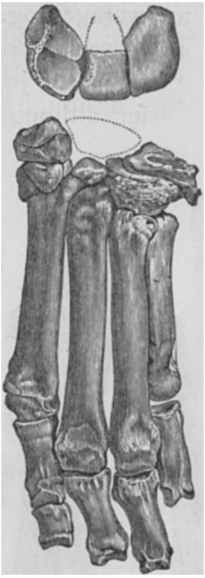

FIG. 7.—*Mesonyx lanius,* left anterior foot, one-half natural size. Upper figure first row of carpal bones of right side of same individual, proximal view. Original. From the Bridger beds of Wyoming.

The *Mesonyx ossifragus* is the largest species, its skull exceeding that of the grizzly bear in dimensions (Figs. 2, 6, 8, 9 and 10). It was originally found by the writer in the Wasatch beds of New Mexico, and was afterwards found by Mr. Wortman to be not uncommon in the corresponding formation in Northern Wyoming. From material obtained by this gentleman, we can form a general idea of the form and proportions of the *Mesonyx ossifragus.* We can depict an animal as large as a large-sized American black bear, with a long, stout tail and a wide head as large as that of a grizzly bear. The fore limbs are so much shorter than the hind limbs that the animal customarily sat on its haunches when on land. In walking, its high rump and low withers would give it somewhat the figure of a huge rabbit. Its neck was about as long as that of an average dog. Its tread was plantigrade, and its claws like those of various rodents, intermediate between hoofs and claws. The animal, to judge from its otter-like humerus, was a good swimmer, although there is nothing specially adapted for aquatic life in the other bones of its limbs. Its teeth, on the other hand, are of the simple construction of the mammals which have a diet largely composed of fishes. We cannot but consider this animal

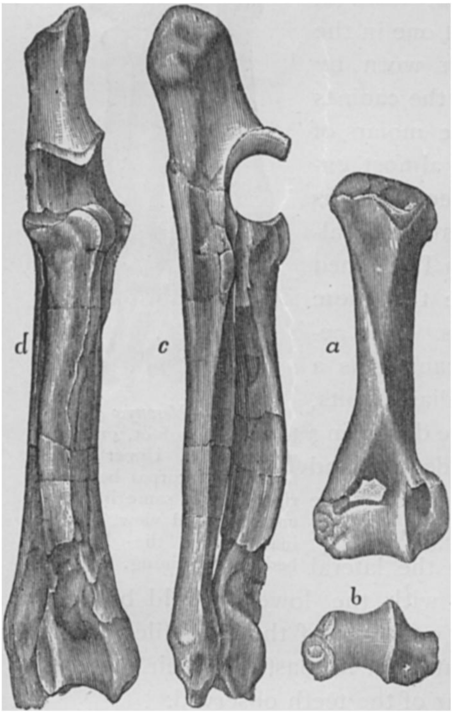

Fig. 8.

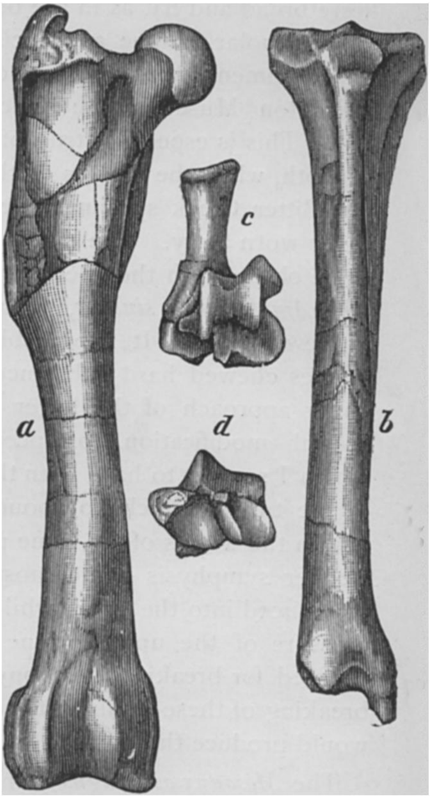

Fig. 9.

FIG. 8.—Anterior limb bones of the specimen of *Mesonyx ossifragus* represented in Figs. 2 and 6, one-third natural size. Fig. *a*, humerus from front; *b*, distal view of distal extremity; *c*, right ulna and radius, external view; *d*, the same from above. FIG. 9.—Posterior limb of *Mesonyx ossifragus*, the individual represented in Figs. 2, 6 and 8, one-third nat. size. Fig. *a*, femur from front; *b*, tibia from front; *c*, astragalus and calcaneum from above; *d*, the same, distal view. From the Big Horn region of the Wasatch epoch.

as one of the most singular which the Eocene period possessed. In size it was not exceeded by any other flesh-eater of the period, but was equaled by the *Protopsalis tigrinus*. Its anterior limbs were evidently relatively shorter than in the *Mesonyx lanius*.

The *Sarcothraustes antiquus* is a large animal from the Puerco epoch of New Mexico, of about the size of the *Mesonyx ossifragus*. Its inferior molars have a wide heel as in Amblyctonus. The genus Dissacus Cope, occurs in the same formation and locality. Its inferior molars (Fig. 11) present an accessory cusp on the inner side of the principal cone. This constitutes the first step towards the tubercular-sectorial tooth of other families. There are two species, the *D. navajovius*, as large as the red fox, and *D. carnifex* Cope, of larger size.

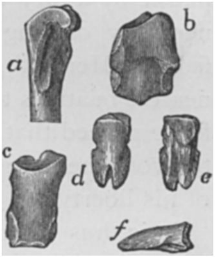

FIG. 10. — Parts of digits of *Mesonyx ossifragus*, one-half natural size. Fig. *a*, metacarpal; *b*, metapodial, distal end; *c*, phalange; *d e f*, an ungual phalange from above, below and side. Original. From the Wasatch beds of Wyoming.

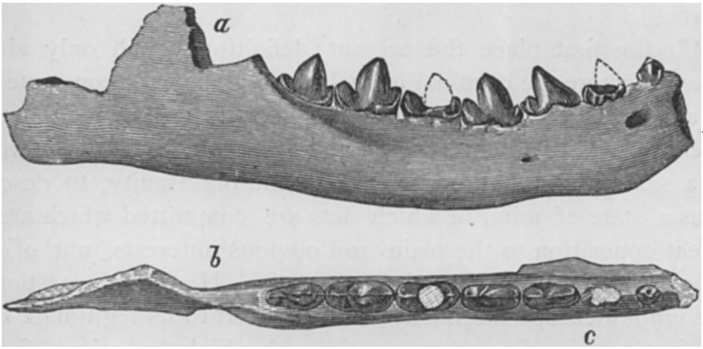

FIG. 11.—*Dissacus navajovius* Cope, right mandibular ramus, three-fourths natural size; *a*, external; *b*, superior views. From the Puerco beds of New Mexico. Original.

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EDITORS' TABLE.

EDITORS: A. S. PACKARD, JR., AND E. D. COPE.

—— That the ordinary jury is incompetent to deal with nice questions of mental status which come before our courts receives frequent proof. And this will always be the case so long as the question of "responsibility" is permitted to complicate the question. Two recent verdicts bring this subject before us at the